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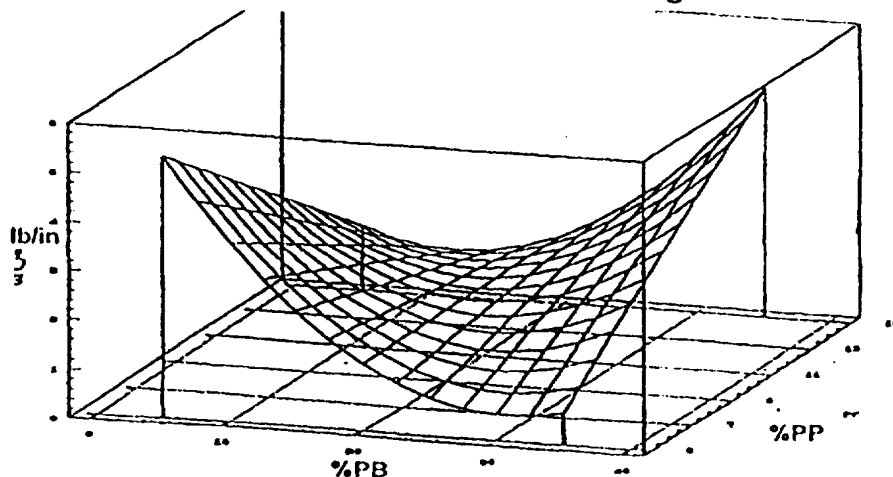
(54) Title: PEELABLE-SEAL COMPOSITIONS AND SEALANT FILM LAYERS

## (57) Abstract

The present invention pertains to peelable seal compositions and peelable seal film structures. The novel compositions are made from at least one homogeneously branched ethylene plastomer, a minor amount of at least one amorphous or elastomeric polymer and a lesser amount of at least one substantially crystalline or crystalline polymer. The compositions and film structure are useful in applications requiring broad heat seal windows such as, for example, cereal liners and packaging.

### Plastomer, PB, PP BLENDS

#### Ultimate Heat Seal Strength



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PEELABLE-SEAL COMPOSITIONS AND SEALANT FILM LAYERS

The present invention relates to an olefin composition having easy open heat seal characteristics and to a sealant film layer comprising a plurality of olefin polymers. In particular, this invention pertains to a peelable seal composition comprised of a homogeneously branched ethylene polymer and minor amounts of two different olefin polymers.

The majority of cereal box liners fall into one of two major categories: waxed-glassine liners or polyolefin film-based structures. Although the use of glassine is reported to be declining, our survey included a surprising number of packages still based on glassine. Glassine is a thin, fully hydrated sheet of paper, which is wax-coated in most applications. Glassine provides excellent barrier; however, it does not exhibit the tensile properties necessary for high packaging speeds. Glassine-based structures traditionally have run on older, slower "Double-Package Makers" (DPM's). New capital investments in packaging are in more compact and efficient vertical form/fill/seal (VFFS) lines. In addition, some DPM's have been rebuilt to run film-based materials. Although turnover of existing packaging equipment is slow, the future for the substitution of glassine with film-based structures is inevitable.

The most common non-glassine liners are coextrusions of HDPE with an ethylene vinyl acetate (EVA)-based seal layer (approximately 18 to 20 weight % VA EVA). Other known liners include a zinc ionomer in the sealant layer. Still another known liners (for a high sugar, high flavor cereal) include coextrusions of high density polyethylene (HDPE), nylon, and an ionomer-based sealant.

The key performance requirements for cereal box liners include moisture barrier, low temperature sealability and good hot tack strength for high line speeds on VFFS packaging lines, abuse resistance, and good taste/ odor performance. There is also the desire to reduce cost via downgauging. This last requirement translates to a need for the sealant layer to contribute to the overall toughness of the structure, especially when very irregularly-shaped cereals are to be packaged.

Another key performance requirement for cereal box liners is an easy open mechanism, or peelable seal. A peelable seal is a heat seal with a defined force, generally in the range of 1 to 10 lb/in for flexible packaging. More specifically, for cereal packaging, a heat seal strength in the range of 1 to 3 lb/in is common, although the target varies according to individual manufacturer's requirements. Controlled, peelable heat seals are desired in flexible packaging applications, such as cereal box liners, cake mix liners, cracker tubes, and snacks, because they offer

integrity (hermetic seals) to ensure quality, but also allow for easy access to the product without the use of tools or destruction of the package.

Known peelable seal compositions and sealant layer films generally include blends such as, for example, ionomer/ EVA compositions, EVA/ Polybutylene (PB) compositions, Ethylene acrylic acid (EAA) copolymer/ EVA compositions, EAA/ PB compositions, and even EVA/ PB/ polypropylene (PP) compositions.

Films and seals produced from polybutylene-based formulations are known to "age down" with time. Accordingly, a correlation of peel seal strength directly off-line to aged seal strengths is normally generated for the purpose of film quality control. Depending on the blend composition, blend ratios, and fabrication techniques, seal strengths predictably age downward 20 to 60%.

In cereal packaging, packages must withstand puncture from irregularly-shaped cereal. Also, as packages are downgauged to improve economics, puncture resistance of the sealant becomes more important. Also, for cereal packaging, the majority of packages are based on HDPE and, therefore, optics are of a lesser concern. For niche applications where package appearance is a key performance requirement, sealant layers and film structures or liners with improved optical properties are desired.

A low heat seal initiation temperature is desirable for obtaining faster packaging line speeds. A broad seal range, or a range of temperatures where ultimate seal strength is constant, is desired. This allows packagers to compensate for packaging equipment that is not precisely tuned in terms of seal temperatures. Also, it allows the package to be more forgiving to changes in packaging speeds. Another property, hot tack, is important in vertical form/fill/seal packaging.

Still another important liner characteristic is its coefficient of friction (COF). COF values are used to determine how well a film will process on a vertical form/fill/seal packaging line. A value of less than 0.2 is generally preferred.

We have discovered that compositions based on homogeneously branched polyolefin plastomers admixed with a plurality of polymer having different relative crystallinities offer improved performance as peelable seal compositions and sealant film layers. Film layers comprised of such compositions exhibit low seal initiation temperatures, good heat seal strengths, and excellent hot tack performance. In addition, they offer outstanding optics and abuse resistance and good taste and odor characteristics. Their performance characteristics, as sealant layers for liners, closely match the requirements for dry food packaging applications.

One aspect of the present invention is a peelable sealant composition comprising at least one homogeneously branched ethylene plastomer, a minor amount of at least one amorphous or elastomeric polymer and a lesser amount of at least one substantially crystalline or crystalline polymer.

Another aspect of the present invention is a film having at least one peelable sealant film layer, the at least one peelable sealant film layer comprising at least one homogeneously branched ethylene plastomer, a minor amount of at least one amorphous or elastomeric polymer and a lesser amount of at least one substantially crystalline or crystalline polymer.

Another aspect of the present invention is in a method for making a peelable seal film structure having at least two layers, comprising the steps of:

- (i) feeding a polymer composition into a sealant layer coextrusion extruder,
- (ii) feeding a polymer composition into a skin layer coextrusion extruder,
- (iii) optionally feeding a polymer composition into a core or structural layer coextrusion extruder,
- (iv) melting and mixing the polymer compositions at melt temperatures above their melting points to form at least two molten polymer streams,
- (vi) extruding the molten polymer streams through a coextrusion feedblock into a slot die to form a web or into an annular die to form a tube having a sealant layer and a skin layer,
- (vii) blowing up and cooling said tube or drawing down and cooling the web to form the peelable seal film structure, and
- (viii) collecting the film structure for subsequent use,

the improvement comprising feeding to the sealant layer coextrusion extruder a polymer composition comprising at least one homogeneously branched ethylene plastomer, a minor amount of at least one amorphous or elastomeric polymer and a lesser amount of at least one substantially crystalline or crystalline polymer.

Another aspect of the present invention is a peelable seal film structure comprising at least one peelable sealant film layer and at least one additional film layer wherein the additional film layer is selected from the group consisting of a polyamide, polyethylene, polypropylene and polycarbonate and the peelable sealant film layer comprising at least one homogeneously branched ethylene plastomer, a minor amount of at least one amorphous or elastomeric polymer and a lesser amount of at least one substantially crystalline or crystalline polymer.

Compositions and sealant film layers of the present invention offer the advantages of minimum off-odor characteristics and excellent optical properties compared to other specialty sealant polymers. One of the surprising results of the present invention is that the compositions and sealant film layers of the present invention maintain the low seal initiation characteristics of the homogeneously branched ethylene plastomer.

The term "amorphous or elastomeric polymer" as used herein is used in the conventional sense and refers to polymers having a relative crystallinity less than about 30 percent, preferably less than about 25 percent, more preferably less than about 15 percent, and most preferably less than about 10 percent as determined using X-ray diffraction techniques.

The term "substantially crystallinity or crystalline" as used herein is used in the conventional sense and refers to polymers having a relative crystallinity greater than about 30 percent, preferably greater than about 45 percent, more preferably greater than about 55 percent, and most preferably greater than about 65 percent as determined using X-ray diffraction techniques.

A combination of polyolefin plastomer with a minor amount of an amorphous or elastomeric polymer and a lesser amount of a substantially crystalline or crystalline polymer exhibit improved peelable seal behavior. Blend ratios can be chosen to reach a target peel strength based on the seal performance requirements for a specific application. The weight percent of the amorphous or elastomeric polymer will be from about 1 to less than about 50 weight percent, preferably from about 4 to about 45 weight percent, more preferably from about 15 to about 42 weight percent and most preferably from about 30 to about 40 weight percent. The weight percent of the substantially crystalline or crystalline polymer will be from about 1 to about 20 weight percent, preferably from about 2 to about 16 weight percent, more preferably from about 2 to about 12 weight percent and most preferably from about 3 to about 9 weight percent.

The homogeneously branched ethylene plastomer can be a substantially linear ethylene interpolymers or a homogeneously branched linear ethylene

polymer. By the term "plastomer" it is meant the polymer is a semi-crystalline polymer of such a relative crystallinity that it would not be generally recognized as an elastomer or amorphous polymer. For homogeneously branched substantially linear ethylene interpolymers, the subset that would be recognized as a plastomer generally have polymer densities greater than about 0.89 g/cc and are supplied by The Dow Chemical Company under the designation AFFINITY polyolefin plastomers. Suitable homogeneously branched linear ethylene polymers are supplied by Mitsui Petrochemical under the designation TAFMER resin and by Exxon Chemical Corporation under the designations EXACT resins and EXCEED resins.

Suitable amorphous or elastomeric polymers for use in the present invention include, but are not limited to, atactic polypropylene resins, atactic poly (1-butene) resins, and homogeneously branched ethylene elastomers. Preferred amorphous or elastomer polymers are substantially linear ethylene polymers and are supplied by Dupont Dow Elastomers under the designation ENGAGE polyolefin elastomers.

Suitable substantially crystalline or crystalline polymers for use in the present invention include, but are not limited to, polypropylene resins, polyethylene resins, polyamides, polybutylene resins and polycarbonates. Preferred polypropylene resins for use in the present invention as the at least one substantially crystalline or crystalline polymer are isotactic or syndiotactic polypropylene resins. Suitable polybutylene resins are isotactic poly (1-butene) homopolymers and isotactic poly (1-butene-ethylene) copolymers such those supplied by Shell Development Company under the designation of DURAFLEX. Preferred polyethylene resins for use as the at least one substantially crystalline or crystalline polymer in the present invention are high density polyethylene resins having a density of at least 0.94 g/cc and are ethylene homopolymers or interpolymers of ethylene and at least one C<sub>3</sub>-C<sub>20</sub>  $\alpha$ -olefin.

Average film thickness for the film structures or liners made in accordance with the present invention range from 1.5 to 2.6 mils (0.04 to 0.07 mm). For high-sugar content cereals, liner thicknesses will generally be thicker than those of the low- or no-sugar cereals.

The compositions can be made via any known technique, including, but not limited, dry blending and extrusion melt mixing of component polymers and in situ polymerizations and interpolymerizations that involve multiple reactors and/or multiple catalyst systems.

#### EXAMPLES

In an evaluation to provide a peelable seal composition with improved seal performance and abuse properties several olefin polymers were studied.

The polymers and polymer concentrates utilized to produce various films in this evaluation are listed in Table I.

For physical property testing, samples were fabricated into two mil (50 micron) monolayer blown films on a unit equipped with a 24:1 L/D, 2-1/2 inch (63.5 mm) extruder and a 6 inch (152.4 mm) die. The blow-up-ratio (BUR) was 2.5:1 for all samples. The polyolefin plastomer was run utilizing a 70 mil (1780 micron) die gap and a melt temperature of approximately 400°F (205°C). The EVA copolymer and the ionomer were processed as recommended by the manufacturer at a 40 mil (1,020 micron) die gap for both and at melt temperatures of 400°F (204°C) and 440 °F (227°C), respectively.

Two mil (50 micron) coextrusions of HDPE/sealant (75/ 25 layer ratio) were fabricated on a three layer blown coextrusion line equipped with two 24:1 L/D, 2-1/2 inch (63.5 mm) and one 24:1 L/D, 2 inch (50.8 mm) extruders and an 8 inch (203.2 MM) 3-layer coextrusion die. The die was equipped with a 70 mil (1,780 micron) die pin insert. The BUR was 2.25:1.

All films and seals were allowed to age a minimum of 48 hours before testing. After 24 hours, blends in this study ranged in average COF from 0.13 to 0.23 with the majority being less than 0.2 COF. A slight adjustment in slip/antiblock levels may be necessary to achieve the desired COF, depending on requirements of the packager.

Physical properties of the monolayer films (optics, dart impact, tear resistance) were determined via ASTM procedures. Puncture resistance was determined using an Instron tensiometer equipped with a strain cell and an integrated digital display that provides force determinations. A single ply of the blown monolayer films were mounted taut between the two halves of a circular holder constructed of aluminum and machined to couple the halves securely when joined together. The exposed film area when mounted in the holder is 4 inches (10.2 cm) in diameter. The holder is then affixed to the upper stationary jaw of the tensiometer. To the lower jaw of the tensiometer which is set to traverse upwardly, a hemispherical aluminum probe having a 12.5 mm diameter is affixed. The probe is aligned to traverse upwards through the center of the mounted film at a deformation rate of 250 mm/min. The force required to rupture the film is taken from the digital display and divided by the film thickness and the diameter of the probe to provide puncture resistance in kg-m/cc.

Polyolefin plastomers exhibited excellent abuse resistance (dart impact, puncture resistance, tear resistance) and optics compared to the Eva and ionomer sealant polymers (Table III).

To determine heat seal strengths, one inch (25 mm) wide strips were mounted on a Topwave Hot Tack Tester, Model DTC 52D. Heat seal conditions included a dwell time of 0.5 second and a seal pressure of 40 psi (0.275



Mpa). Seals were stored at ASTM conditions (22°C, 50% RH) for >48 hours and then pulled on an Instron tensiometer at a crosshead speed of 10 in/min (250 mm/min). Heat seal strengths are reported in pounds/inch (lb./in) (g/mm). For this study, heat seal initiation temperature was defined as the temperature at which 1 lb/in (18 g/mm) heat seal strength was obtained.

Hot tack measurements were also performed on a Topwave Hot Tack Tester: seal time of 0.5 second, delay time of 0.2 second, peel speed of 150 mm/ second, and seal pressure of 40 psi (0.275 Mpa). Hot tack is recorded in Newtons (N)/25mm width.

Sensory data was generated using trained panelists to evaluate film samples in a ranking format or paired comparison, as specified. The samples were coded with random three digit numbers and presented according to a balanced block design in order to minimize bias. Evaluations were conducted in an air medium. Panelists smelled the backs of their hands between odor samples in order to zero out their sense of smell. Data was analyzed using a Friedman Analysis of Variance followed by Duncan Multiple Range comparisons.

In another evaluation, a designed experiment was performed. The polyolefin plastomer was blended with a PB copolymer and a PP homopolymer to form the sealant layer in coextruded blown film. The sealant layers contained a constant level of 2500 ppm slip and 5000 ppm antiblock, added via concentrates in a polyolefin plastomer base resin.

The evaluation was set up as a 3 level, 2 variable full factorial with repeated center points. Independent variables were PB and PP blend ratios. Dependent variables were seal initiation temperature, sealing temperature range, ultimate seal strength, and hot tack strength.

Based on preliminary range finding experiments, the range of weight percent polybutylene was set from about 5 to about 35 weight percent and polypropylene was varied from about 5 to about 15 weight percent base on the total weight of the sealant composition. Thirteen formulations were dry-blended to prepare the sealant layer for the two-layer blown coextruded film samples (Table II).

In order to determine the response of seal properties to the controlled variables, experimental data were mathematically modeled using the Statgraphics Statistical Analysis Program. This analysis provided equations that related the level of polybutylene and polypropylene to heat seal strength, initiation temperatures, and hot tack values.

In a 2.0 mil (0.05 mm) monolayer blown film comparison, the puncture resistance of the polyolefin plastomer was approximately 20% higher than the EVA copolymer and double that of the ionomer.

Moisture barrier of the polyolefin plastomer was significantly better than the EVA copolymer (2.0 versus 6.2 g-mil/ 100 sq. in-day-atm.) (79 versus 244 g-cm/sq. m-day-atm.).

Heat seal strengths were measured on HDPE/sealant coextrusions where the sealant layer was the plastomer, EVA copolymer or the ionomer (Figure 1). Compared to the other polymers, the polyolefin plastomer exhibited excellent heat seal strength over a wide temperature range. The heat seal initiation temperature of the plastomer was 3°C below that of the EVA copolymer and 15°C lower than the ionomer.

Hot tack strengths were also measured on HDPE/ sealant coextrusions (Figure 2). The ultimate hot tack strength of the polyolefin plastomer was much higher (70 to 120 percent higher) than either that of the EVA copolymer or the ionomer.

Using sensory evaluation techniques, a 35 member test panel ranked samples from least to most intense (with a value of 3 as most intense) to compare the odor characteristics of the plastomer to the ionomer (Figure 3). The plastomer received the most neutral response (lesser value) when compared to the ionomer, at confidence levels greater than 90 percent. In a separate paired comparison test, 24 of 24 panelists identified the plastomer as exhibiting lower off-odor compared to the EVA copolymer. The EVA copolymer was typically described as having an "acidic, sharp, or sour" odor.

Heat seal values and initiation temperatures obtained from the experimental design were reviewed and entered into Statgraphics for analysis. As defined in the introduction, a value between 1 and 3 pounds (0.45 and 1.36 kg) is a common target heat seal strength for a peelable seal. The standard deviation for heat seal testing was 0.5 lb/in (89 g/cm). The surface response plot for the results is shown in Figure 4.

Table I

## POLYMERS AND ADDITIVE CONCENTRATES FOR FILM STRUCTURES

Polymer	Product	Description
Polyolefin plastomer (POP)	AFFINITY* PF1140	1.6 MI, 0.8965 g/cc
Ionomer	Surlyn** 1652	5.5 MI, Zn ion
EVA copolymer (EVA)	Elvax** 3165	0.8 MI, 18%VA
Polypropylene (PP)	Exxon PP4062	3.6 MI, 0.900 g/cc density homopolymer
Polybutylene (PB)	Duraflex*** PB8640	1.0 MI, 0.908 g/cc copolymer
Slip concentrate	Ampacet 100329	5 wt% Erucamide in polyolefin plastomer base
Antiblock (AB) concentrate	Ampacet 100342	20 wt% SiO <sub>2</sub> in polyolefin plastomer base
HDPE	Chevron HDPE 9650	0.3 MI, 0.952 g/cc

Table II

## SEALANT BLENDS FOR COEXTRUDED FILMS

Blend #	Wt % Plastomer	Wt % PB	Wt% PP	Wt% Slip Concentrat e	Wt% AB concentrat e
1	82.5	5	5	5	2.5
2	47.5	35	10	5	2.5
3	57.5	20	15	5	2.5
4	62.5	20	10	5	2.5
5	77.5	5	10	5	2.5
6	62.5	20	10	5	2.5
7	42.5	35	15	5	2.5
8	67.5	20	5	5	2.5
9	72.5	5	15	5	2.5
10	62.5	20	10	5	2.5
11	62.5	20	10	5	2.5
12	52.5	35	5	5	2.5
13	92.5	0	0	5	2.5

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Table III

## MONOLAYER FILM PHYSICAL PROPERTIES OF SEALANT POLYMERS

Property	Test Method	Polyolefi n Plastomer	EVA Copolymer	Ionomer
<b>Abuse Resistance<sup>1</sup></b>				
Dart Impact, g	ASTM D1709, Method B	>830	650	434
Tear Resistance, g	ASTM D1922, Method B	300	118	190
Puncture Resistance, ft-lb/cu in (kg-m/cc)	Dow Method	270 (2.3)	222 (1.9)	10 (0.9)
<b>Optics<sup>1</sup></b>				
Percent Haze	ASTM D1003	1.3	1.5	2.9
45° Gloss	ASTM D2457	92	85	79
<b>Sealability<sup>2</sup></b>				
Heat Seal Initiation Temp (°C), 1 lb./in	HDPE coextrusions	69	72	84
Ultimate Seal Strength, lbs./in (g/mm)	HDPE coextrusions	6.1 (109)	5.5 (98)	5.3 (95)
Hot Tack Strength, N/25 mm	HDPE coextrusions	7.5	3.4	4.4
<b>Barrier Properties<sup>1</sup></b>				
Water Vapor Transmission Rate, g-mil/100 sq in-day-atm (g-cm/sq. m- day-atm.)	ASTM 1434	2.0 (79)	6.2 (244)	N/A

<sup>1</sup> 2.0 mil (0.05 mm) monolayer blown films<sup>2</sup> 1.5 mil (0.04 mm) HDPE/ 0.5 mil (0.01 mm) sealant coextruded blown films

Table IV

## PLASTOMER, PB, PP BLENDS

<u>Wt % Plastomer</u>	<u>Wt % PB</u>	<u>Wt % PP</u>	<u>Seal Window(°C)</u>
90	5	5	5
75	20	5	17
60	35	5	37
90	5	5	5
85	5	10	19
80	5	15	16
90	5	5	5
70	20	10	13
50	35	15	11

PB denotes polybutylene resin; PP denotes polypropylene resin.

## WHAT IS CLAIMED IS:

1. A peelable sealant composition comprising at least one homogeneously branched ethylene plastomer, a minor amount of at least one amorphous or elastomeric polymer and a lesser amount of at least one substantially crystalline or crystalline polymer.

2. The composition of Claim 1 wherein the homogeneously branched ethylene plastomer is a substantially linear ethylene interpolymer characterized as having:

- i. a short chain branching distribution index (SCBDI) greater than 50 percent,
- ii. a single differential scanning calorimetry, DSC, melting peak between  $-30^{\circ}$  and  $150^{\circ}\text{C}$ ,
- iii. a melt flow ratio,  $I_{10}/I_2$ ,  $\geq 5.63$ ,
- iv. a molecular weight distribution,  $M_w/M_n$ , defined by the equation:  
$$M_w/M_n \leq (I_{10}/I_2) - 4.63$$
, and
- v. a gas extrusion rheology critical shear rate wherein the critical shear rate at the onset of surface melt fracture for the substantially linear ethylene polymer is at least 50 percent greater than the critical shear rate at the onset of surface melt fracture for a linear ethylene polymer, wherein the linear ethylene polymer is characterized as having an  $I_2$ ,  $M_w/M_n$  and density within ten percent of the substantially linear ethylene polymer, and wherein the critical shear rates of the substantially linear ethylene polymer and the linear ethylene polymer are measured at the same melt temperature using a gas extrusion rheometer.

3. The composition of Claim 1 wherein the homogeneously branched ethylene plastomer is a linear ethylene interpolymer characterized as having:

- i. a short chain branching distribution index (SCBDI) greater than 50 percent, and
- ii. a single differential scanning calorimetry, DSC, melting peak between  $-30^{\circ}$  and  $150^{\circ}\text{C}$ .

4. The composition of Claim 1 wherein the at least one amorphous or elastomeric polymer is an olefin polymer selected from the group

consisting of an atactic polypropylene resin, an atactic poly (1-butene) resin, and a homogeneously branched ethylene elastomer.

5. The composition of Claim 4 wherein the at least one amorphous or elastomeric polymer is an atactic polypropylene resin.

6. The composition of Claim 4 wherein the at least one amorphous or elastomeric polymer is a homogeneously branched substantially ethylene elastomer having a polymer density less than 0.89 g/cc.

7. The composition of Claim 1 wherein the at least one substantially crystalline or crystalline polymer is a polymer selected from the group consisting of a polypropylene resin, a polyethylene resin, a polyamide resin, a polybutylene resin and a polycarbonate resin.

8. The composition of Claim 7 wherein the at least one substantially crystalline or crystalline polymer is a homopolymer polypropylene resin.

9. The composition of Claim 7 wherein the at least one substantially crystalline or crystalline polymer is an isotactic or syndiotactic polypropylene resin.

10. The composition of Claim 7 wherein the at least one substantially crystalline or crystalline polymer is a polybutylene resin.

11. The composition of Claim 1 wherein the at least one substantially crystalline or crystalline polymer has a crystallinity of at least 30 percent as measured by X-ray diffraction analysis.

12. A film having at least one peelable sealant film layer, the at least one peelable sealant film layer comprising at least one homogeneously branched ethylene elastomer, a minor amount of at least one amorphous or elastomeric polymer and a lesser amount of at least one substantially crystalline or crystalline polymer.

13. A method of making a peelable seal film structure having at least two layers, comprising the steps of:

- (i) feeding a polymer composition comprising at least one homogeneously branched ethylene elastomer, a minor amount of at least one amorphous or elastomeric polymer and a lesser amount of at least one substantially

- crystalline or crystalline polymer into a sealant layer coextrusion extruder,
- (ii) feeding a polymer composition into a skin layer coextrusion extruder,
  - (iii) optionally feeding a polymer composition into a core or structural layer coextrusion extruder,
  - (iv) melting and mixing the polymer compositions at melt temperatures above their melting points to form at least two molten polymer streams,
  - (vi) extruding the molten polymer streams through a coextrusion feedblock into a slot die to form a web or into an annular die to form a tube having a sealant layer and a skin layer,
  - (vii) blowing up and cooling said tube or drawing down and cooling the web to form the peelable seal film structure, and
  - (viii) collecting the film structure for subsequent use.

14. A peelable seal film structure comprising at least one peelable sealant film layer and at least one additional film layer wherein the additional film layer is selected from the group consisting of a polyamide, polyethylene, polypropylene and polycarbonate and the peelable sealant film layer comprising at least one homogeneously branched ethylene plastomer, a minor amount of at least one amorphous or elastomeric polymer and a lesser amount of at least one substantially crystalline or crystalline polymer.

15. The film structure of Claim 14 wherein the at least one additional film layer comprises at least one high density polyethylene resin.

16. The composition of Claim 1, the method of Claim 13 and the film of Claim 14 wherein the homogeneously branched ethylene plastomer is a homogeneously branched linear ethylene interpolymer characterized as having a short chain branching distribution index (SCBDI) greater than 50 percent.

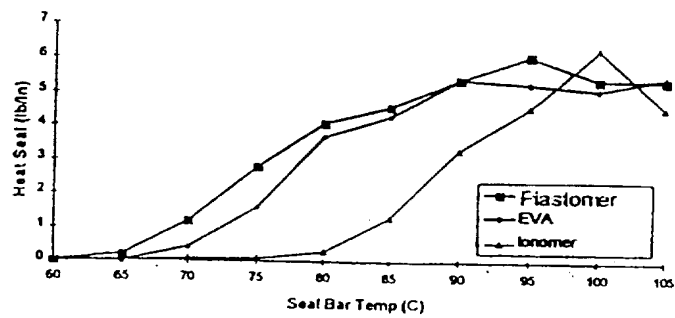
17. The method of Claim 13 and the film of Claim 14 wherein the homogeneously branched ethylene plastomer is a substantially linear ethylene interpolymer characterized as having:

- i. a short chain branching distribution index (SCBDI) greater than 50 percent,
- ii. a single differential scanning calorimetry, DSC, melting peak between -30° and 150°C,



- iii. a melt flow ratio,  $I_{10}/I_2 \geq 5.63$ ,
- iv. a molecular weight distribution,  $M_w/M_n$ , defined by the equation:  
$$M_w/M_n \leq (I_{10}/I_2) - 4.63, \text{ and}$$
- v. a gas extrusion rheology critical shear rate wherein the critical shear rate at the onset of surface melt fracture for the substantially linear ethylene polymer is at least 50 percent greater than the critical shear rate at the onset of surface melt fracture for a linear ethylene polymer, wherein the linear ethylene polymer is characterized as having an  $I_2$ ,  $M_w/M_n$  and density within ten percent of the substantially linear ethylene polymer, and wherein the critical shear rates of the substantially linear ethylene polymer and the linear ethylene polymer are measured at the same melt temperature using a gas extrusion rheometer.

Figure 1  
HDPE Coextrusions  
Heat Seal Strength



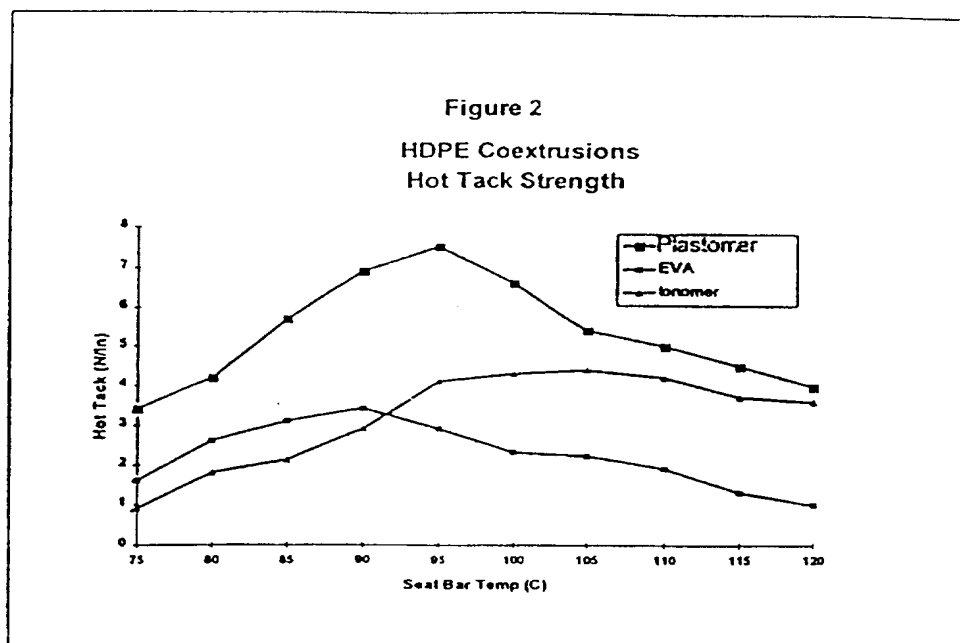
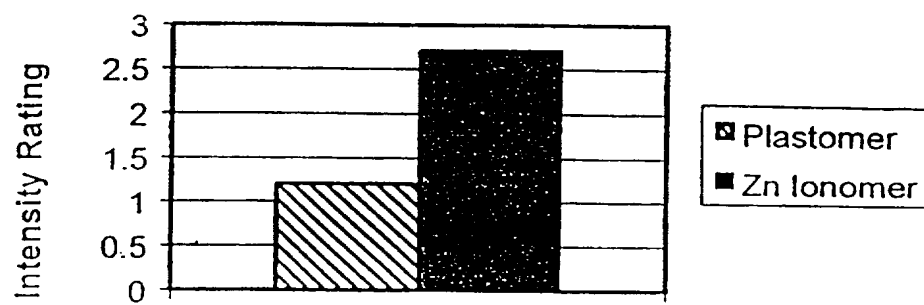
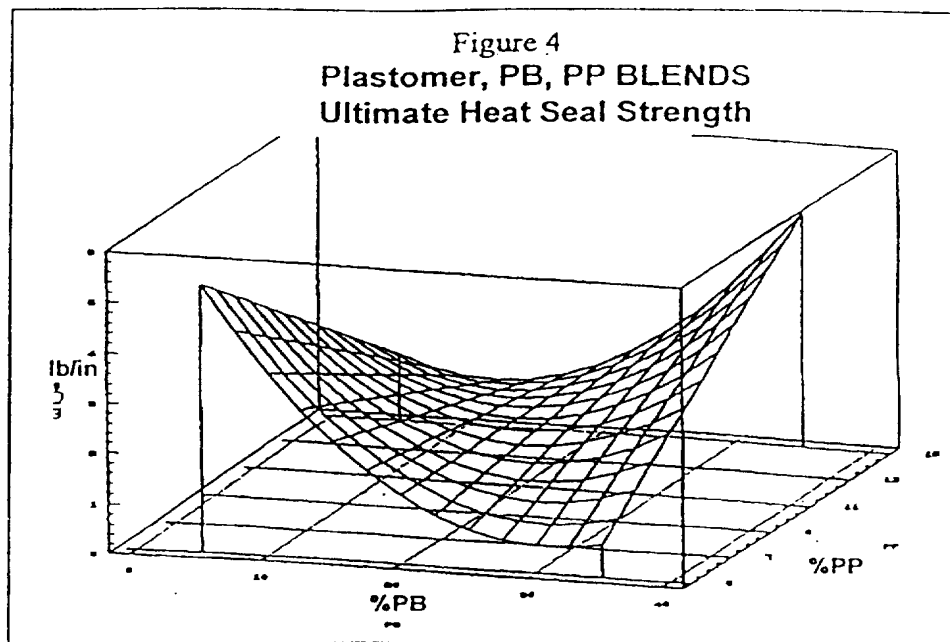
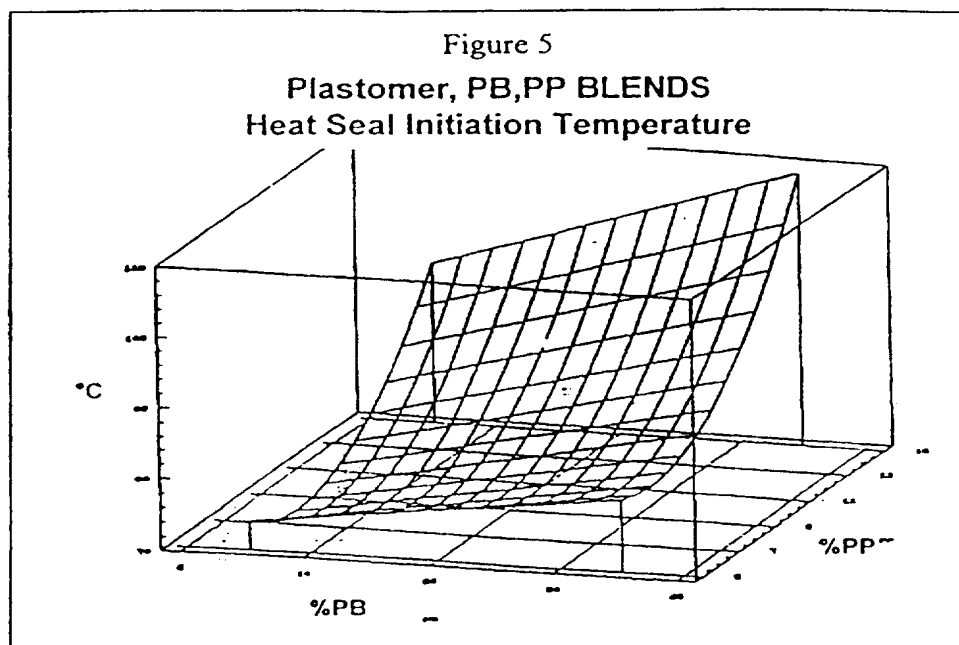
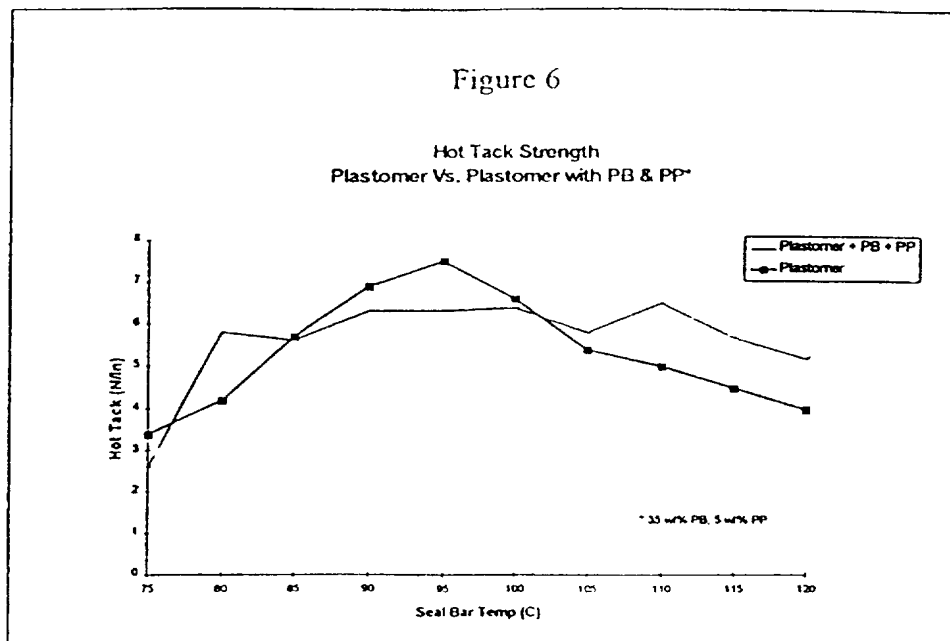


Figure 3  
Sensory Evaluation: Off Odor  
Intensity









# INTERNATIONAL SEARCH REPORT

International Application No  
PCT/US 97/10625

## A. CLASSIFICATION OF SUBJECT MATTER

IPC 6 B32B27/32 C09K3/10 C09J123/04 C08L23/04 B32B27/08

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 C09J B32B C09K C08L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

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	-/-	

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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\*Z\* document member of the same patent family

Date of the actual completion of the international search

9 October 1997

Date of mailing of the international search report

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## INTERNATIONAL SEARCH REPORT

International Application No

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